The International Wheat Yield Partnership (IWYP) – An Effective Model for Integrating Wheat Science to Increase Yield Potential

***Jeff Gwyn**, Mark Sawkins, Richard Flavell - IWYP*

1st International Wheat Congress

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Research to Deliver Wheat for the Future

"The electric light did not come from the continuous improvement of candles"

Oren Harari

"If I had asked people what they wanted, they would have said faster horses"

Henry Ford

The International Wheat Yield Partnership (IWYP)

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- Every scientist here knows how complicated and difficult it is not only to make innovative improvements in crop productivity, but also have them incorporated into the products that make it to farmers' fields
- IWYP was founded:
  - To tackle the complexity of integrating the trait and genetic outputs for yield enhancement from cutting-edge discovery science
  - To assemble these innovations in elite germplasm to significantly enhance the genetic yield potential to address the "global grand challenge" of food and nutritional security for the future
- To do so, IWYP created a holistic system to take discoveries from many international research teams, translate and scale them into pre-products for use in breeding higher yielding varieties for both the developed and developing parts of the world

What is IWYP ?

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- IWYP takes the lead responsibility for delivering one of the four core themes of the Wheat Initiative's 'Strategic Research Agenda'
- IWYP is a unique public-private partnership:
  - Set up to maximize efficiency in bringing together the top international science in a specific target area
  - To coordinate an integrated program and drive its science toward delivery and impact
- IWYP is a long term Program – it will take many years to translate, develop and scale the number of research outputs in the pipeline and deliver the innovations via breeding to farmers' fields

IWYP Research and Funding Partners (14)

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WHEAT INITIATIVE

USAID FROM THE AMERICAN PEOPLE

UKaid from the British people

GRDC Grains Research & Development Corporation

BBSRC 20 Years of Pioneering Great British Bioscience

USDA United States Department of Agriculture National Institute of Food and Agriculture

USDA United States Department of Agriculture Agricultural Research Service

syngenta foundation for sustainable agriculture

INRA SCIENCE & IMPACT

CGIAR

सत्यमेव जयते
Department of Biotechnology
Ministry of Science & Technology
Government of India

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

SADER SECRETARÍA DE AGRICULTURA Y DESARROLLO RURAL

CIMMYT International Maize and Wheat Improvement Center

IWYP Private Industry Partners (9)

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syngenta

mahyco® EVERY SEED COUNTS

Limagrain from earth to life

CORTEVA™ agriscience

KWS®

BASF We create chemistry

SEED·CO The African Seed Company

RAGT 2n

LongReach

IWYP Stakeholders Drive the Initiative

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Funding Organizations and Private Industry Partners **Invest**:

- ✓ Considerable time in strategy development and science oversight
- ✓ ~US$ 55M in research projects
- ✓ ~US$ 5M in the downstream translation and development platform
- ✓ ~US$ 3M in Program Coordination and Management
- ✓ By further developing the outputs in their breeding pipelines

International Teams of Scientists **Innovate**:

- ✓ Discover or create the novel scientific outputs to increase genetic yield potential
- ✓ Actively participate in the overall IWYP Science Program
- ✓ Create added value through integration of their science with others

IWYP Targets Specific Areas of Science to Seek "Breakthroughs" in Wheat Genetic Yield Potential

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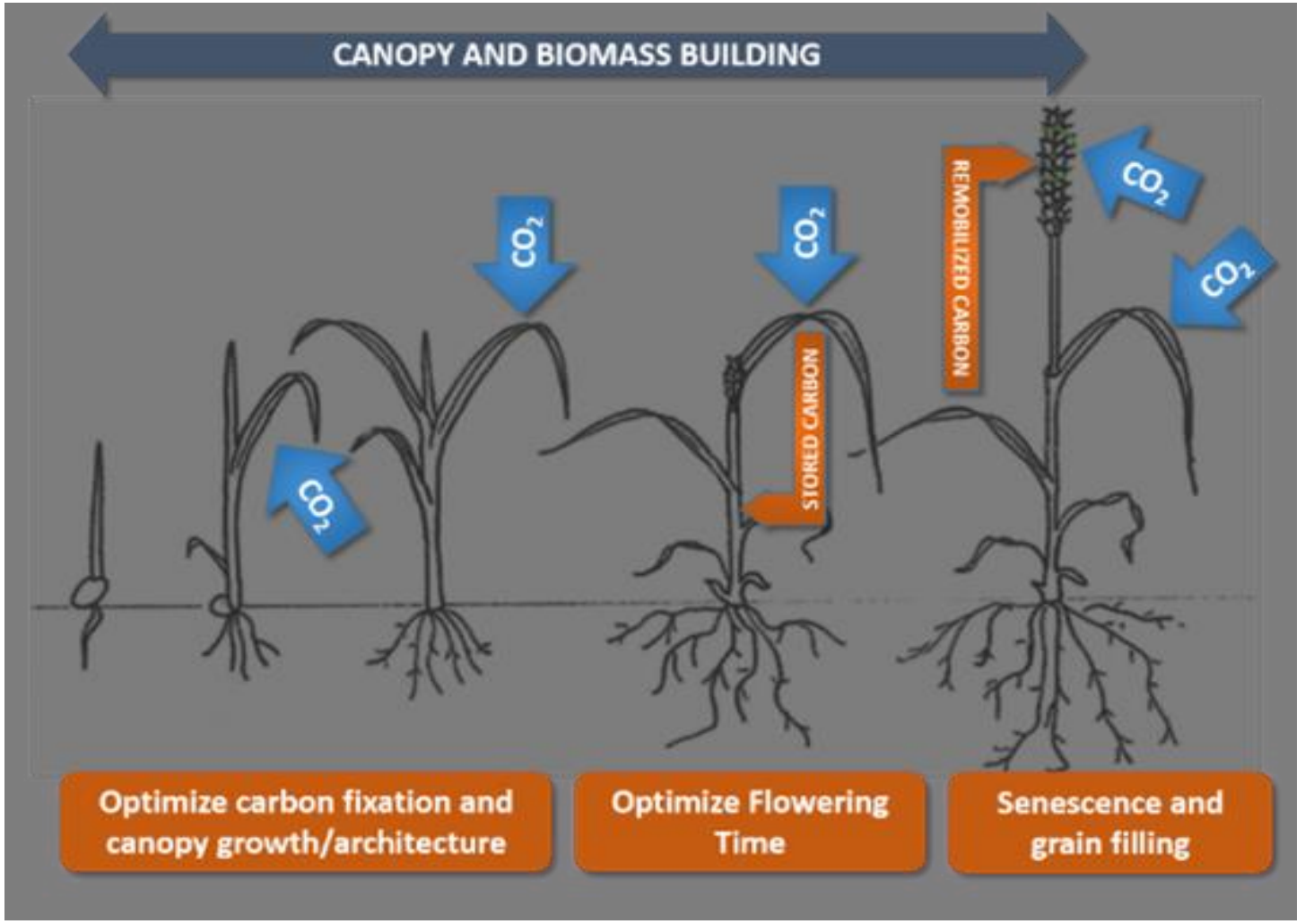
Primary Focus

- ✓ Enhance photosynthesis to drive yield increases - both source and sink sides of the equation, and connections between
- ✓ Optimize resource uptake, distribution and utilization



How IWYP Operates – Purposely Different Approach

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- Organizes IWYP-led competitive Calls and selects international teams and their projects to meet IWYP goals and objectives
- Participates in "Aligned Calls" with Funding Agency Partners
- Brings in relevant research funded outside of IWYP mechanisms to expand the science base

- Coordinates scientific outputs for increasing wheat yield potential and integrates them to generate added value
- Manages an organized translation and development pipeline (IWYP Hub) for scaling selected outputs (traits, markers, tools, germplasm) by validating innovations in the field, combining them in elite germplasm, then transferring them to field trialing systems
- Feeds the improved lines (pre-products) into existing varietal breeding pipelines, both public and private, to create new products for impact

Current IWYP Research Portfolio

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IWYP Science Program is made up of 38 “hand-picked” overlapping and / or complementary research projects, conducted by top international scientists working collaboratively to provide the essential building blocks that will be used to create novel pre-products

Number of Projects	**38**
Number of Countries	**14**
Number of Institutions	**58**
Number of Researchers	**150+**

The IWYP Hub Sorts, Assembles and Scales the Trait/Marker/Tool Outputs in Path to Impact

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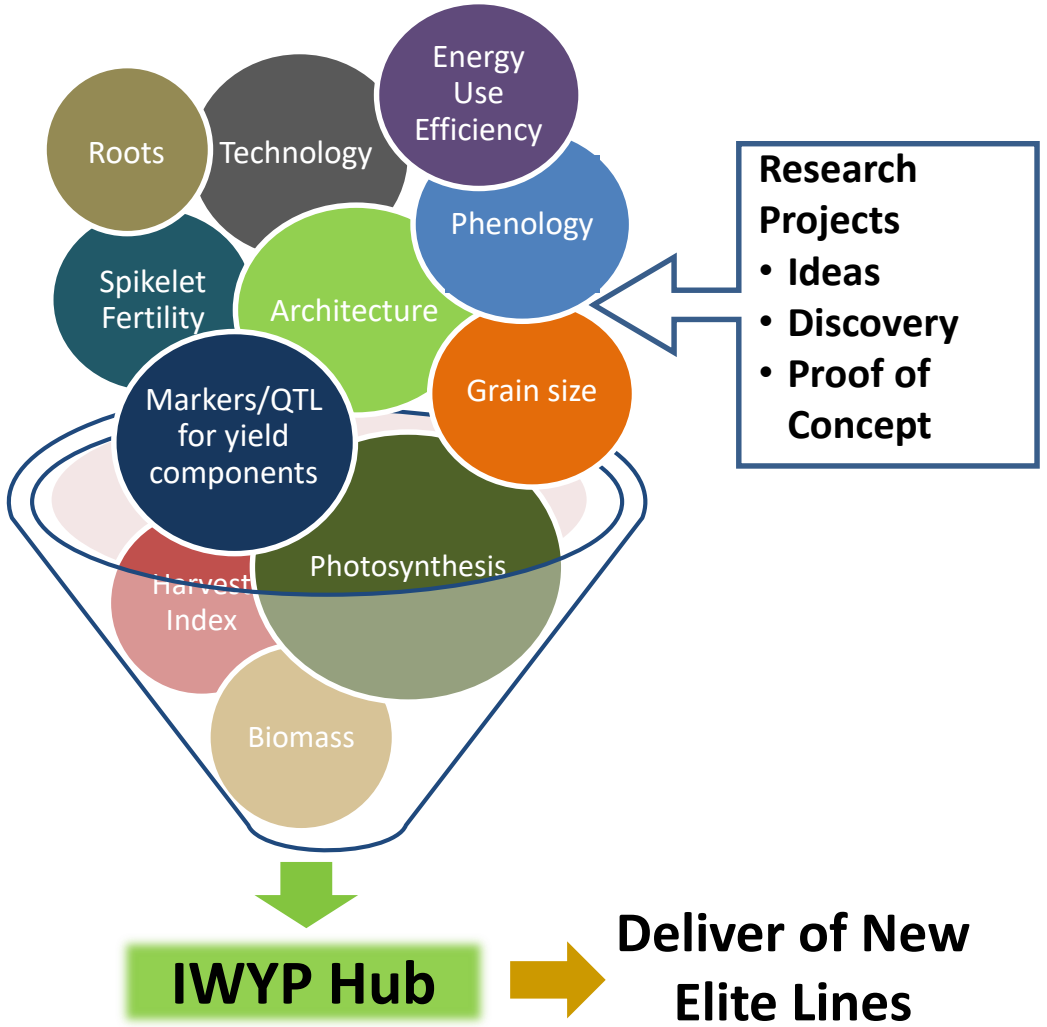
HUB Platform approach for Translation

- Brings all discoveries into a single central source to compare and combine to seek synergies and generate added value
- Enables IWYP to scale the innovations and drive the discoveries/traits toward the market

✓ Trait validation
✓ Precision phenotyping
✓ Prebreeding
✓ Field evaluation in relevant environments
✓ Distribution of novel higher yielding germplasm



Expanding the IWYP Downstream Network

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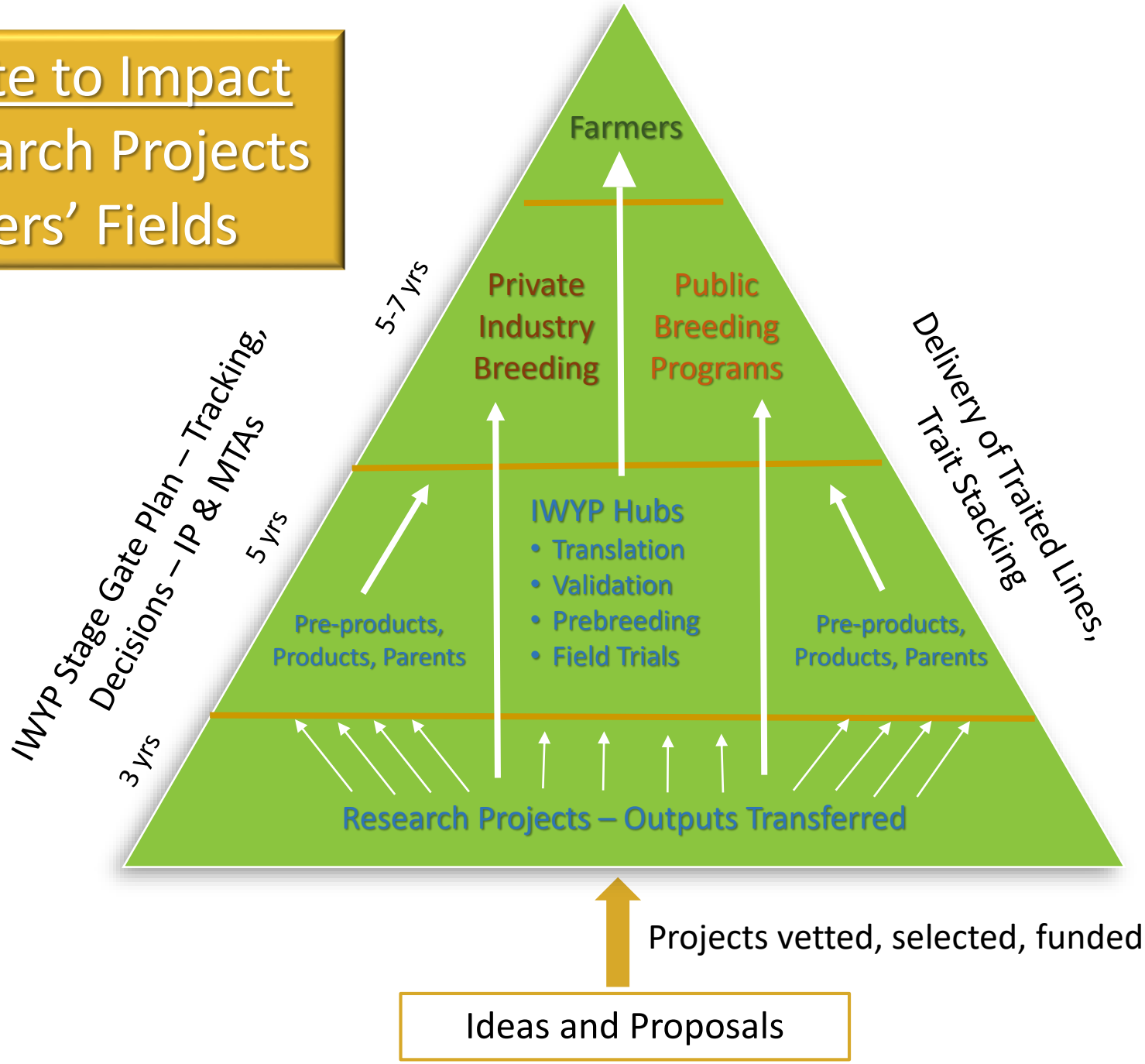
- Will enhance the capability to serve the channels to market for both developed and developing countries
- Main research, translation and development IWYP Hub is with CIMMYT – spring wheats
- Working to install 2 different Winter Wheat Hub centers, one in the US and another in the UK / Europe - expecting significant cross over and sharing

IWYP Route to Impact
From Research Projects to Farmers' Fields



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Organizing and Tracking IWYP Steps and Processes

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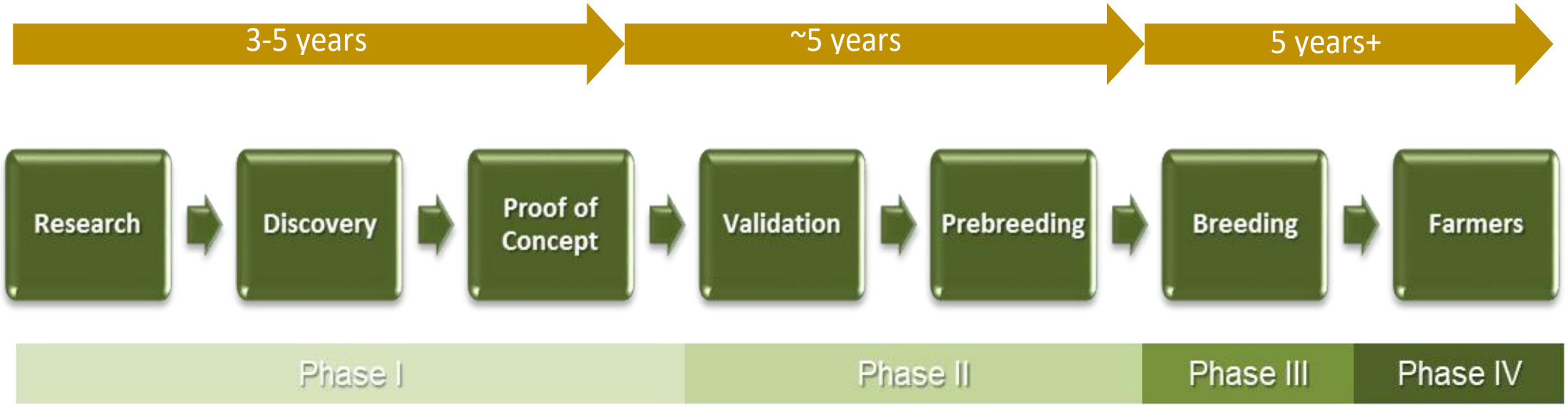
IWYP's Strategic Plan fall into 4 overlapping "phases"



IWYP STAGE GATE PROCESS

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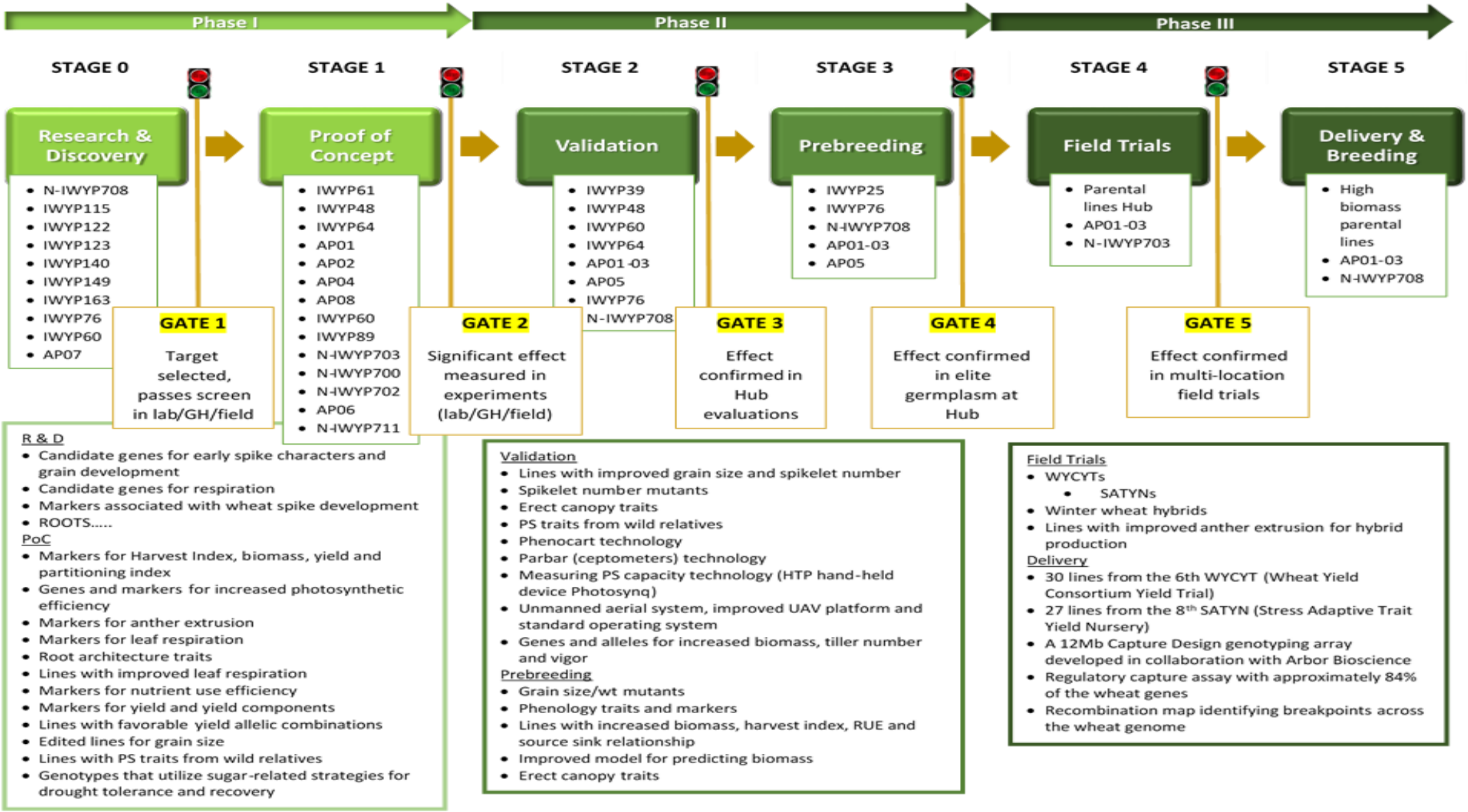

R & D
- Candidate genes for early spike characters and grain development
- Candidate genes for respiration
- Markers associated with wheat spike development
- ROOTS.....

PoC
- Markers for Harvest Index, biomass, yield and partitioning index
- Genes and markers for increased photosynthetic efficiency
- Markers for anther extrusion
- Markers for leaf respiration
- Root architecture traits
- Lines with improved leaf respiration
- Markers for nutrient use efficiency
- Markers for yield and yield components
- Lines with favorable yield allelic combinations
- Edited lines for grain size
- Lines with PS traits from wild relatives
- Genotypes that utilize sugar-related strategies for drought tolerance and recovery

Validation
- Lines with improved grain size and spikelet number
- Spikelet number mutants
- Erect canopy traits
- PS traits from wild relatives
- Phenocart technology
- Parbar (ceptometers) technology
- Measuring PS capacity technology (HTP hand-held device Photosynq)
- Unmanned aerial system, improved UAV platform and standard operating system
- Genes and alleles for increased biomass, tiller number and vigor

Prebreeding
- Grain size/wt mutants
- Phenology traits and markers
- Lines with increased biomass, harvest index, RUE and source sink relationship
- Improved model for predicting biomass
- Erect canopy traits

Field Trials
- WYCYTs
  - SATYNs
- Winter wheat hybrids
- Lines with improved anther extrusion for hybrid production

Delivery
- 30 lines from the 6th WYCYT (Wheat Yield Consortium Yield Trial)
- 27 lines from the 8th SATYN (Stress Adaptive Trait Yield Nursery)
- A 12Mb Capture Design genotyping array developed in collaboration with Arbor Bioscience
- Regulatory capture assay with approximately 84% of the wheat genes
- Recombination map identifying breakpoints across the wheat genome

The IWYP Science Program – Examples of Progress in Our Research to Illustrate the Strategy

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Hypothesis – More efficient photosynthesis, e.g., through RUE and/or EUE is a major bottleneck for yield enhancement

- IWYP seeks to mine and capitalize on genetic variation that has been under-appreciated by screening diverse germplasm for specific traits in ways that have never been done before
- Research is identifying traits associated with photosynthesis (both source and sink) and respiration, and how they are effected by the environment, e.g., sun/shade transitions
- Further research defines the underpinning genetics of these traits and creates tools for efficient application in breeding
- New technologies make the types of discoveries we are seeking possible, from both the phenotypic and genotypic aspects
- IWYP views the integrated development of research innovations from around the world into usable genetic resources as a distinctive and critical aspect of the Program

Selecting for Increased Biomass (RUE) in Diverse Populations to Increase Source Strength – Found Significant Variability

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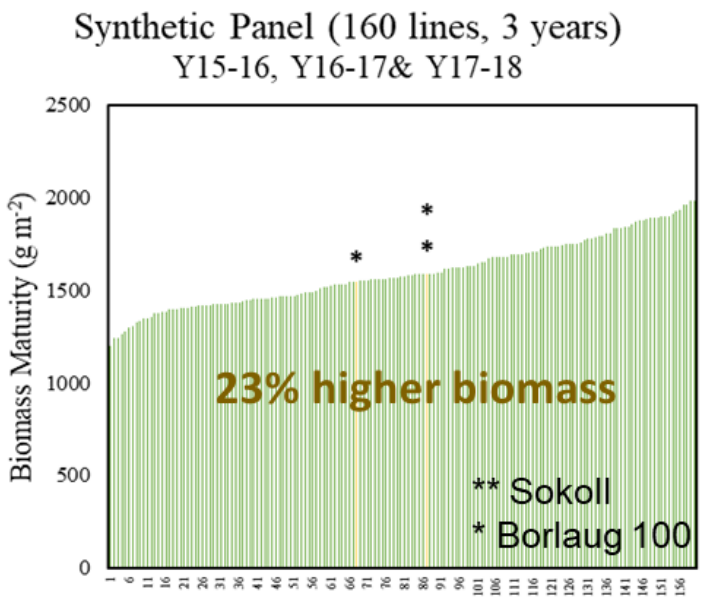

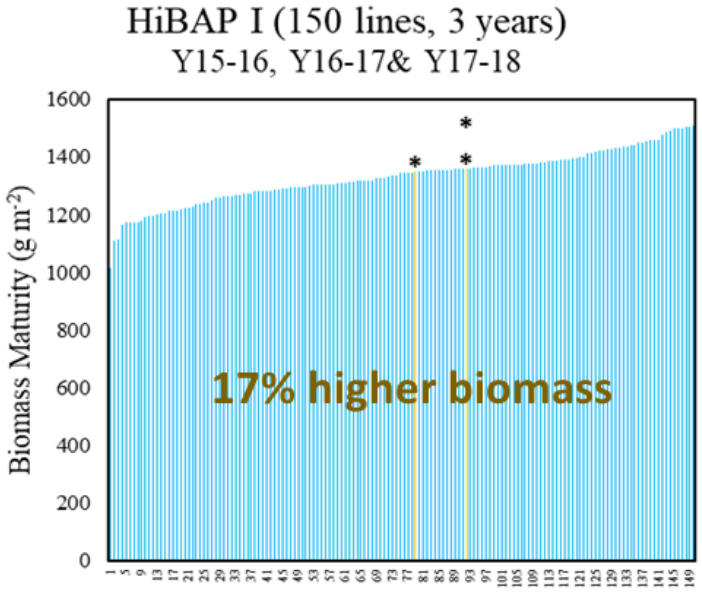

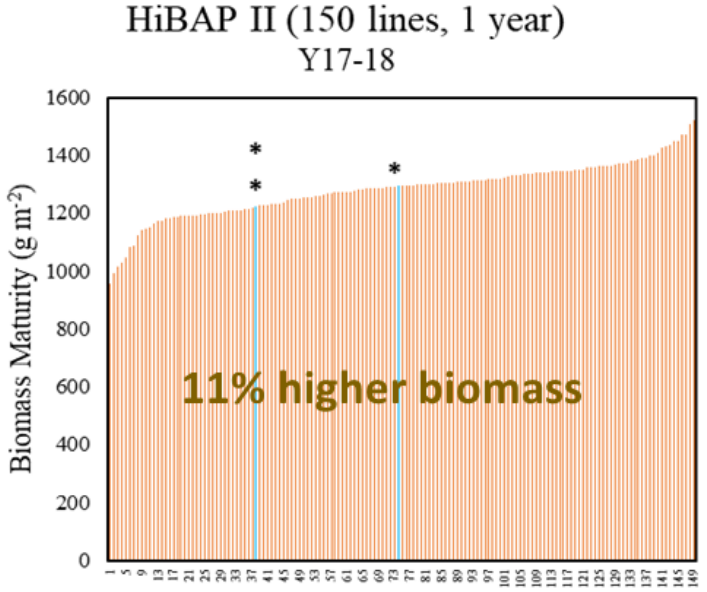

- **Large genetic variation for final biomass** in over 3,500 spring wheat lines evaluated
- Best lines expressing up to **23% higher biomass** than the elite checks
- Highest biomass lines have **exotic** material in their pedigrees

Courtesy of G. Molero & C. Rivera, CIMMYT

Higher Expression of BM, TGW and RUE from Exotic Germplasm – Trade-Offs Need to be Considered

RUE explained 38% of yield variation

Trait	Variable chosen	Adjusted R^2	*P-value*	Sig. *F* change
Yield	RUE_GF	0.382	<0.001	<0.001
	RUE_GF, HI	0.657	<0.001	<0.001
	RUE_GF, HI, BM_PM	0.861	<0.001	<0.001
	HI, BM_PM	0.861	<0.001	0.487
	HI, BM_PM, GM2	0.866	<0.001	0.012

Type	YLD	DTA	TGW	HI	Height	BM_PM	RUE_GF
Elite	597^{A}	76^{B}	42.6^{C}	0.473^{A}	99^{D}	1346^{B}	1.99^{B}
Landrace derivatives	592^{A}	**79^{A}**	**45.7^{B}**	**0.450^{C}**	**103^{A}**	**1394^{A}**	2.02^{AB}
Synthetic derivatives	594^{A}	76^{B}	**45.6^{B}**	**0.463^{B}**	**101^{C}**	1358^{AB}	2.03^{AB}
Synthetic+Landrace derivative	593^{A}	76^{B}	**48.2^{A}**	**0.459^{B}**	**102^{B}**	**1389^{A}**	**2.17^{A}**

Molero, Joynson et al., 2019. Plant Biotechnology Journal

Link Biomass with HI and Select High Yielding Lines

Validates IWYP's Primary Trait Targets

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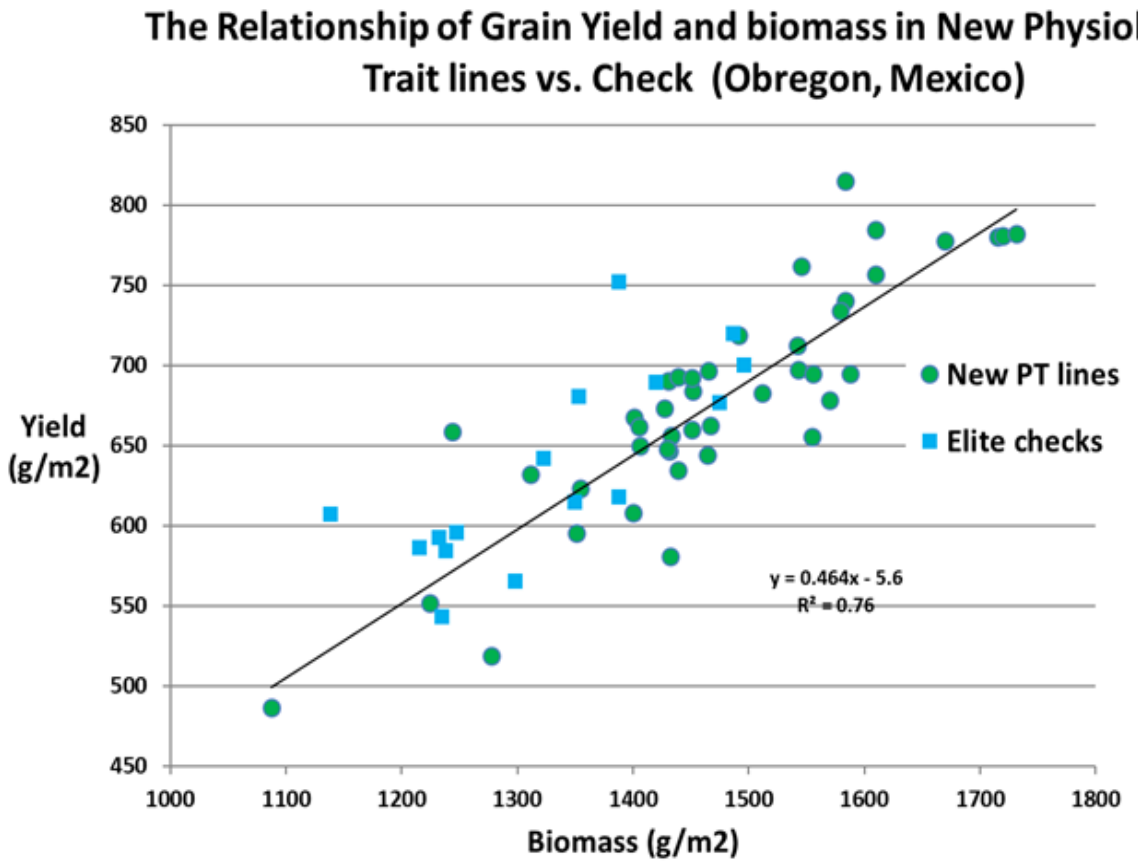

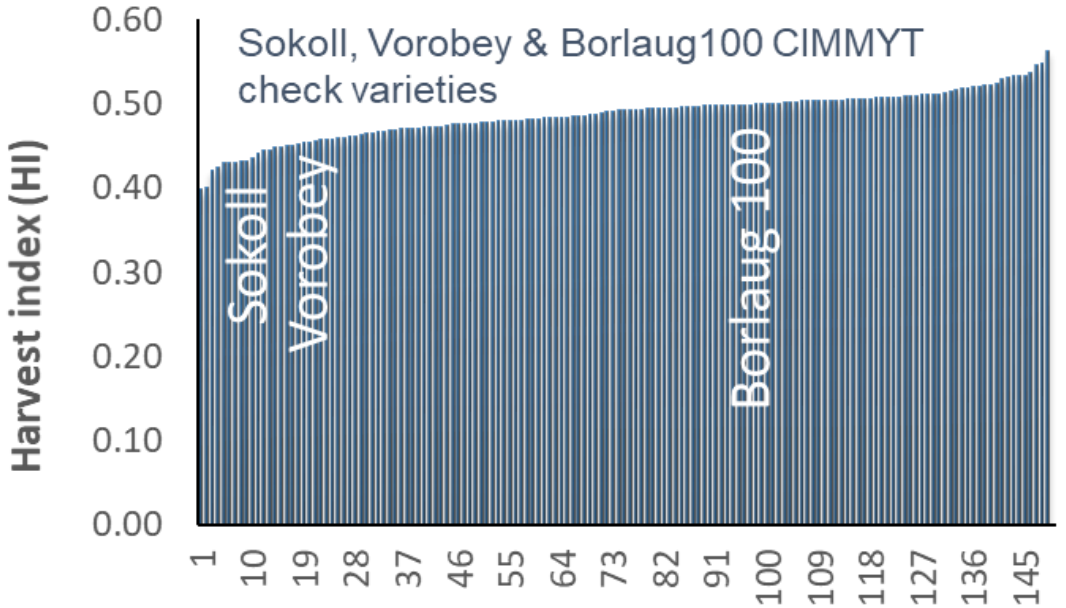

- **Large genetic variation in HI** in high biomass panel (HIBAP II); trade off with biomass
- HI maintained in high biomass lines
- Some lines with up to **13% higher HI** than the CIMMYT variety Borlaug 100

Courtesy of G. Molero, C. Rivera, M. Reynolds, CIMMYT

More Aspects of Source: Altering Canopy Architecture Can Increase Total Photosynthesis and Wheat Yield

Advantages of erect canopies:

- Better light penetration
- Higher grain yield and biomass
- More spikes and more grains
- Less lodging
- Better heat tolerance

Table 1. Percentage change in grain yield and related traits of lines with an erect canopy compared with lines with a floppy canopy at the IWYP Hub 2017/18

	Grain yield	Biomass	Harvest Index	Grain No	Grain size	Spike No	Height	Flowering time
Erect vs. Floppy	12%	8%	4%	47%	-25%	22%	-5%	1%

Courtesy of R. Richards, CSIRO

Respiration and Energy Use Efficiency (EUE) Impacts Grain Yield in Wheat

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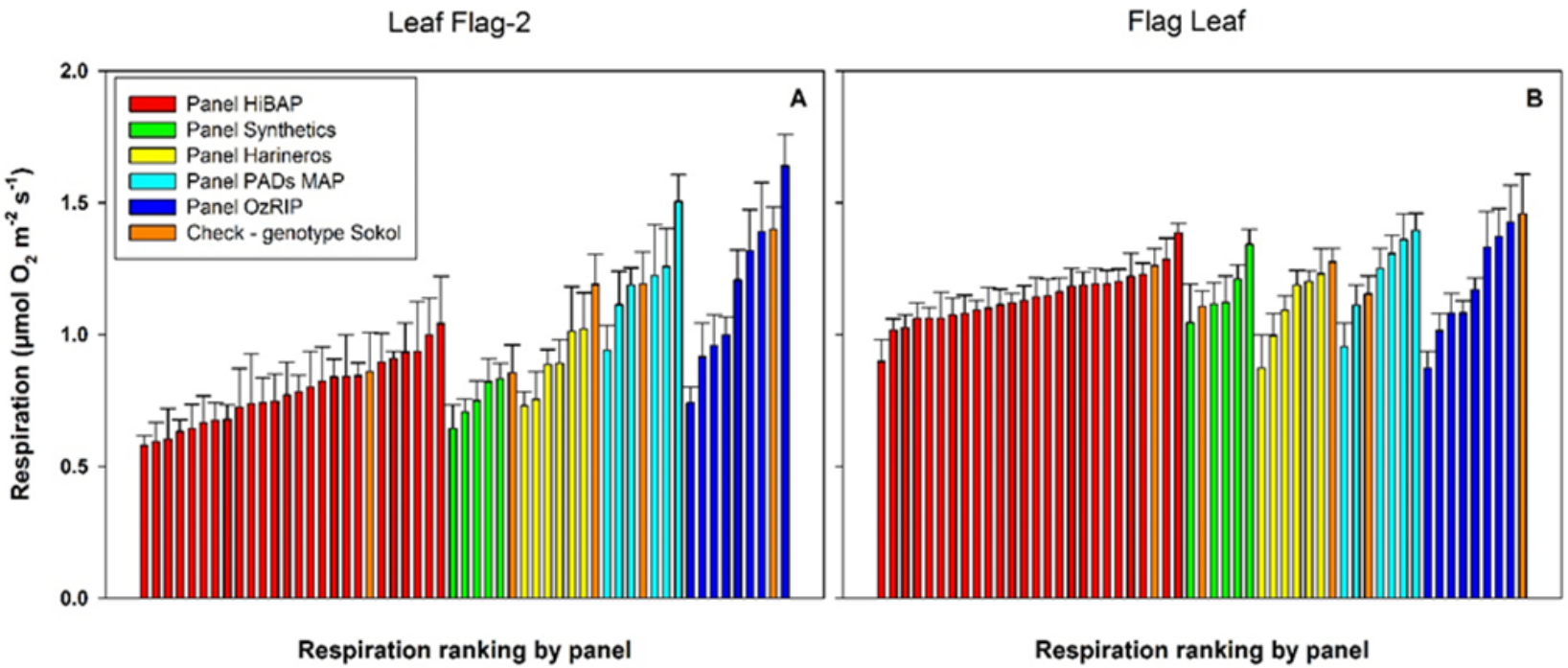
***Respiration Rate (Rd)* is:**

- **Diverse** - 2-3 fold variation found
- **Robust** - Panel rankings vary minimally between years
- **Informative** - *Rd* can be related to biomass and yield measurements

➢ Respiration is negatively correlated with yield

➢ Similar correlations with biomass can also be found



Parameter	2017		2016	
	r	*p*	r	*p*
Leaf R per unit leaf area (µmol O_2 m^{-2} s^{-1})	-0.205	0.192	-0.109	0.650
Leaf R per unit dry mass (nmol O_2 g_{DM}^{-1} s^{-1})	**-0.408**	0.002	**-0.382**	0.041
Leaf R per unit fresh mass (nmol O_2 g_{FM}^{-1} s^{-1})	**-0.306**	0.032	0.170	0.449

Courtesy of B. Pogson, ANU

Identification of QTL for Respiration Rate as a Marker for Selection to Increase EUE in Breeding

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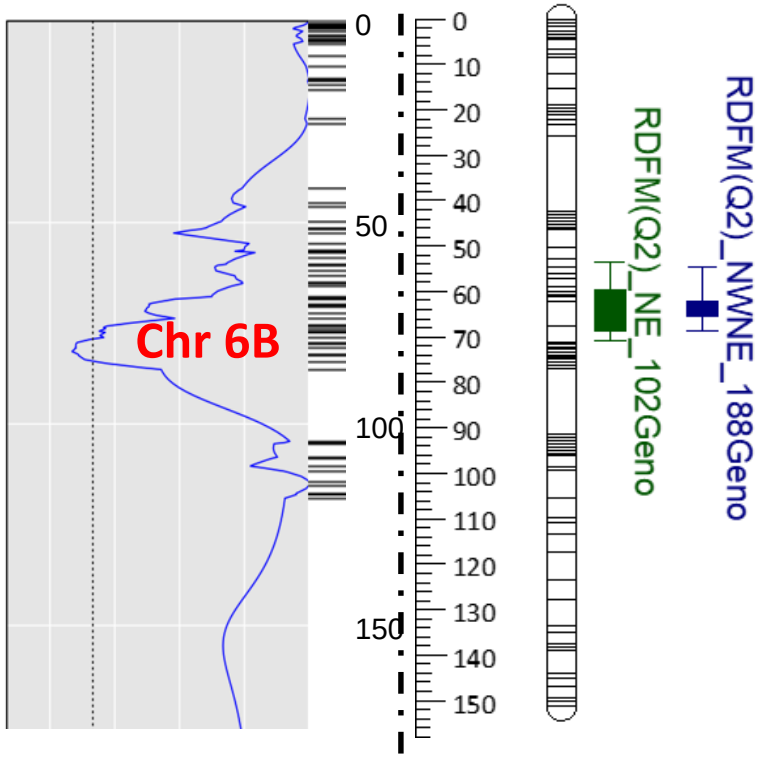
2 Mapping Populations

- Excalibur×Kukri (835 RILs)
- Seri – Babax (177 RILs)

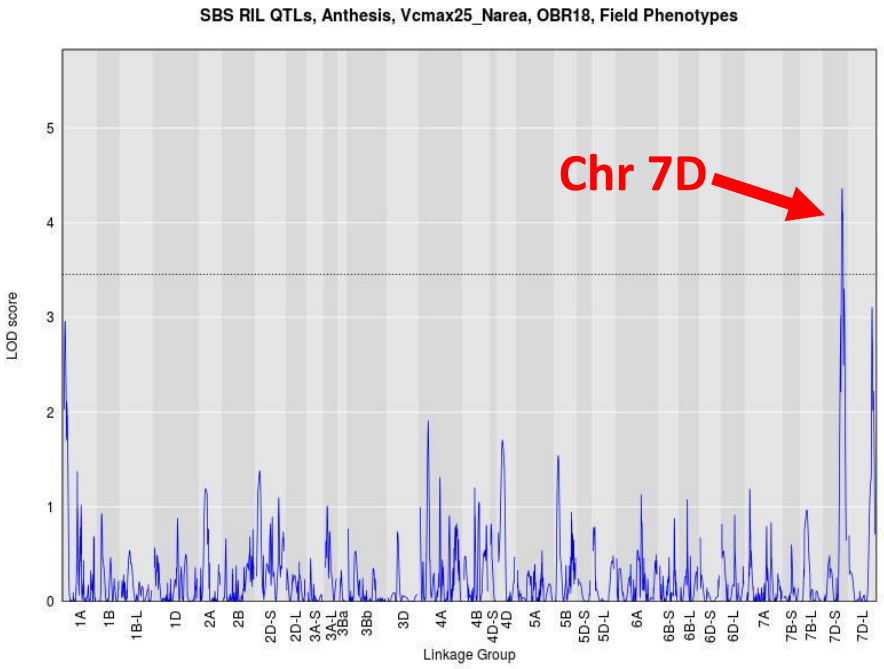
– ***Rd* QTL on Chr 6B**

- Both populations
- No known phenology markers in area
- New GBS map being generated for fine mapping

SBS – Obregon 2017 E×K – Adelaide 20



Identification of QTL for *Rd* in two populations, LOD > 3.5, in two locations. Produced using rqtl and QTL Cartographer.



- **QTL 7D** for Vcmax/Narea in SBS RILs Obregon 2018 at anthesis
- *Mapping in 2 sets of RILs >170 entries 2 sites, 3 seasons*
- *plus Excal / Kukri in Plant Accelerator*

Courtesy of B. Pogson, ANU

Mining Wild Relatives for Enhanced Photosynthetic Traits has Resulted in the Identification of Significant Positive Variation

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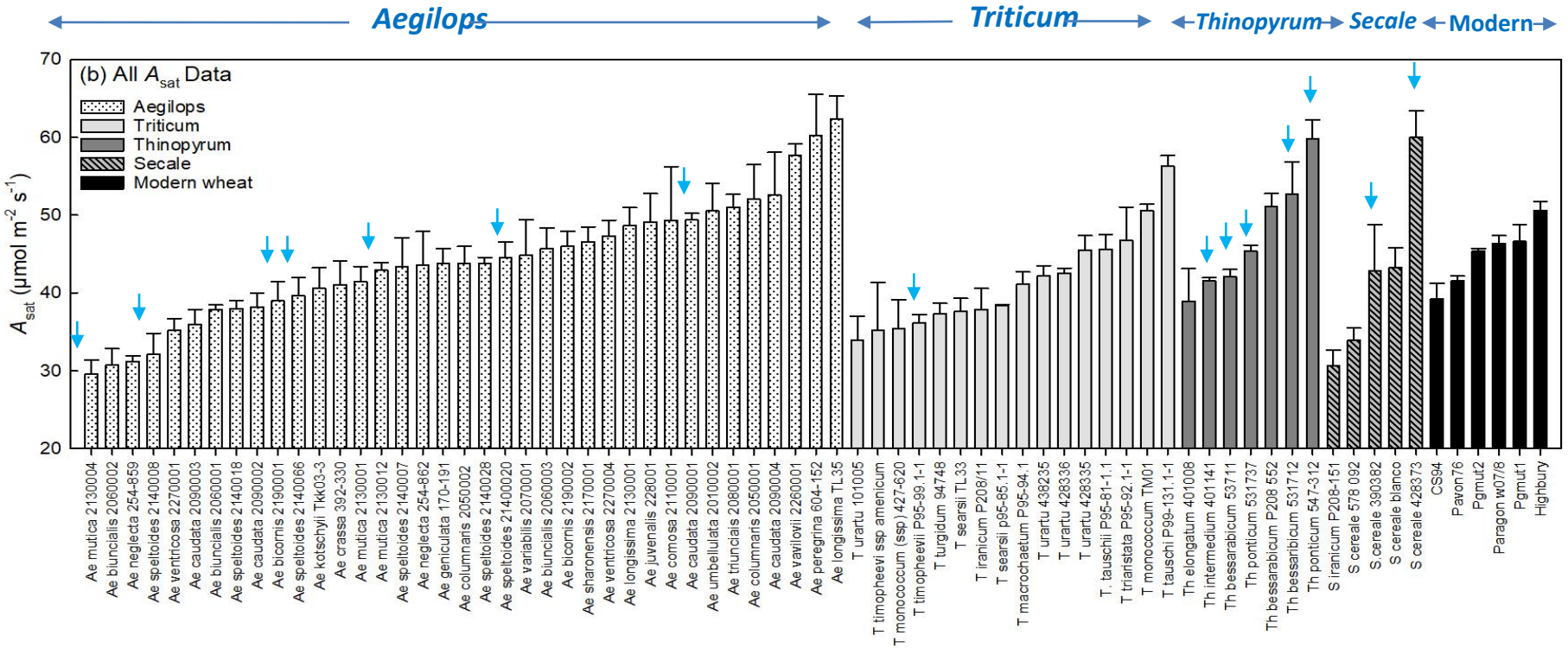
138 wild relative accessions assessed

- A_{sat}, A_{max}, V_{cmax} and J_{max}, photorespiration
- Morphology
- Dynamic photoprotective traits
- ✓ Several-fold difference in photosynthesis
- ✓ Higher than elite lines

27 accessions of interest from 13 species *that show enhanced photosynthesis associated with either: improved electron transport, Rubisco properties, dynamic photosynthesis, leaf morphology, dynamic stomatal responses. Strong theoretical basis……*



23 DH lines derived from *T. urartu* and *Ae. mutica* transferred to the IWYP Hub for field analysis in 2018+2019:

- 3 lines with consistently high photosynthesis (*Asat, Vcmax, Jmax*) and lower nocturnal dark respiration
- Biomass, yield component data & genetic analysis ongoing.
- Crossing with elite lines

Courtesy of E. Murchie, Univ. of Nottingham

Genotyping Selected Lines from Diverse Panels has Identified Many Important Marker-Trait Associations (Use for Breeding)

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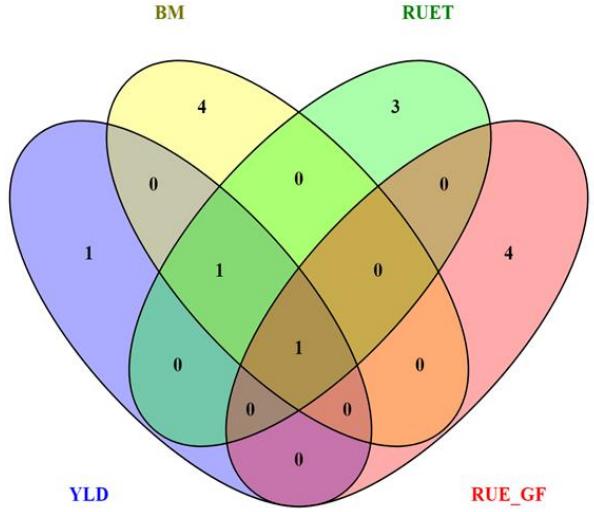
Trait		No. Marker Trait Associations	Chromosomes
Agronomic			
	Grain Yield (g m^{-2})	3	5A, 6A, 7A
	Plants m^{-2}	4	1A, 2B, 3B, 5A
	Stems m^{-2} 40 days emergence	2	2B, 6B
	Stems m^{-2} InB	4	1A, 2D, 3A, 6B
Phenology and phenological patterns			
	Booting initiation (days)	5	2B, 3A, 3D, 5B, 6B
	Days to anthesis	5	2B(2), 3A, 3D(2)
	Rapid spike growth phase(%)	4	1A, 2B(2), 4D
	% grain filling duration	4	3A(2), 3D, 5B
Sink			
	Harvest Index	2	2B, 6A
	Thousand grain weight	2	2D, 6D
	Grains m^{-2}	5	2B, 3B, 5A, 6D, 7B
	Spikes m^{-2}	9	1A(3), 2B, 3B, 5B, 6B(2), 7B
	Grain weight per spike	4	1A, 1B, 2B, 6B
	No. spikelets SP^{-1}	7	1A, 2B(2), 3D(2), 4B, 7A
	Spike (cm)	3	5A, 5B, 7A
Source			
	BM_40 days post emergence (g m^{-2})	2	1B, 3B
	BM_Booting (g m^{-2})	3	2A, 4B, 7A
	BM_Pysiological maturity (g m^{-2})	6	5A, 6A, 7A(2), 7B, 7D
	RUE_E40InB (g MJ^{-1})	4	2A, 2D, 3B. 6A
	RUE_{GF} (g MJ^{-1})	5	1A, 1D, 2A, 5A, 6A
	RUE_{T} (g MJ^{-1})	5	3D, 5A(2), 6A, 7A
	LI_E40 (%)	6	1B, 3B(3), 5A, 6D

Common MTAs between RUE with Yield and Biomass



Trait	Number of MTAs	Chromosomes
BM_E40 (g m^{-2})	2	1B, 3B
BM_InB (g m^{-2})	3	2A, 4B, 7A
BM_PM (g m^{-2})	6	5A, 6A, 7A(2), 7B, 7D
RUE_E40InB (g MJ^{-1})	4	2A, 2D, 3B. 6A
RUE_GF (g MJ^{-1})	5	1A, 1D, 2A, 5A, 6A
RUET (g MJ^{-1})	5	3D, 5A(2), 6A, 7A

Molero, Joynson et al., 2019. Plant Biotechnology Journal

Deployment of Beneficial Alleles (Sink) from Wheat CAP

The WheatCAP students are targeting:

- 6 QTL for grain yield
- 5 QTL for SNS
- 8 QTL for kernel size/weight
- 2 QTL for reproductive tiller number
- Molecular markers are available for the QTL
- Students are provided exome capture data for their parental lines, genotyping of their mapping populations, and training to use the T3 database and tools
- Two projects have cloned their targeted genes, and others are at different stages.
- All programs are backcrossing their QTL into high yield (HY) and high biomass (HB) CIMMYT lines (will test isogenic lines vs. nulls)
- First lines delivered to the IWYP Hub at CIMMYT in 2017

Courtesy of J. Dubcovsky, UC Davis

Table 1. Traits, QTL, donor alleles, CIMMYT recurrent parents and status of crosses.

State	Trait	QTL/Gene	Donor allele	CIMMYT Background [1]	Status
AR	Yield	1A (IWA7173)	AGS 2000	4 HY CIMMYT lines	BC_1
	Yield	6B (IWA755, IWA6428)	AGS 2000	9 HY CIMMYT lines	BC_1
CA	Spikelet No.	7AL 670-680 Mb[2]	Berkut	HB (GID 3855011, 4314513, 4878563)	BC_4
	Spikelet No.	1A^{m}L. *Elf3 =Eps-A^{m}1*	*T. monococcum*	Kingbird / 5 HB CIMMYT	BC_4/BC_2
	Grain Size	6AL *gw-A2*	EMS mutant	Kingbird / 5 HB CIMMYT	BC_4/BC_2
	Combined	*Eps-A^{m}1 + gw-A2*	Same as above	Cirno, Kronos, GID 6420253	BC_4F_2
CO	Kernel weight	6BL 493-503 Mb	Platte	5 HB CIMMYT / CO13D1383	F_1
	Spikelet No	7AL 670-680 Mb	Platte	5 HB CIMMYT / CO13D1383	F_1
ID	Spikelet No.	5AL 631-643 Mb	UI Platinum	4 HB CIMMYT	BC_3
	Productive tillers	6A 91-198 Mb	Capstone	4 HB CIMMYT	BC_3
KS	Yield & diseases	2DL QTL, *Sr57/Yr40,* 2NS	KS11WGGRC53-O	11 HY/HB	BC_2
MI	Yield	2DS 22.1-29.5Mb	KS05HW14	Kingbird & Heilo	BC_1F_1
MN	Grain size	5BS *QTkw.mna-5B*	MN99394-1	HB (3855011, …13, ...63, ...69)	BC_2F_2
MT	Productive tillers	6B *QTn.mst-6B* 150Mb	Reeder	HB (GID 3613474)	BC_2
NC	Grain weight	6A	Massey	HY/HB	F_1
	Awns	5A, *B1* awn suppressor	Multiple	HY/HB	F_1
ND	Grain wgt./spike	2BL *QGws.fcu-2B*	Ben	Kingbird, GID4878569, 4577963, 3613474.	F_1/BC_1
NY	Grain wgt./width	5AL (66 cM)	Opata	6 HY/ HB CIMMYT, Tom, Glenn	$BC_{1\text{-}2}$
	Grain length	5BL1 (40.5 cM)	Synthetic W9784	6 HY/ HB CIMMYT, Tom, Glenn	$BC_{1\text{-}2}$
OK	Yield	*QYld.osu*-1B (25 Mb reg.)	Duster	HY/ HB CIMMYT	F_1
	Spikelet No.	7BL, 650-700 Mb	CItr17600 (L20)	HY/ HB CIMMYT	F_1
SD	Yield	7DS, 6-16 Mb	*Ae. tauschii* TA1615	Kingbird, GID4314513,3613474, Ideal	F_1
TX	Grain weight	2BS, 65.5 Mb	TAM 111	4 HB CIMMYT	F_1 /BC_1
WA	Grain No/weight	4AL	Scarlett grain wgt.	HB CIMMYT[3]	BC_2

[1] CIMMYT recurrent parents for high biomass =HB and for high yield =HY.

Increasing Yield Components to Realize Yield Gains Involves Strategies to Mitigate Trade-Offs

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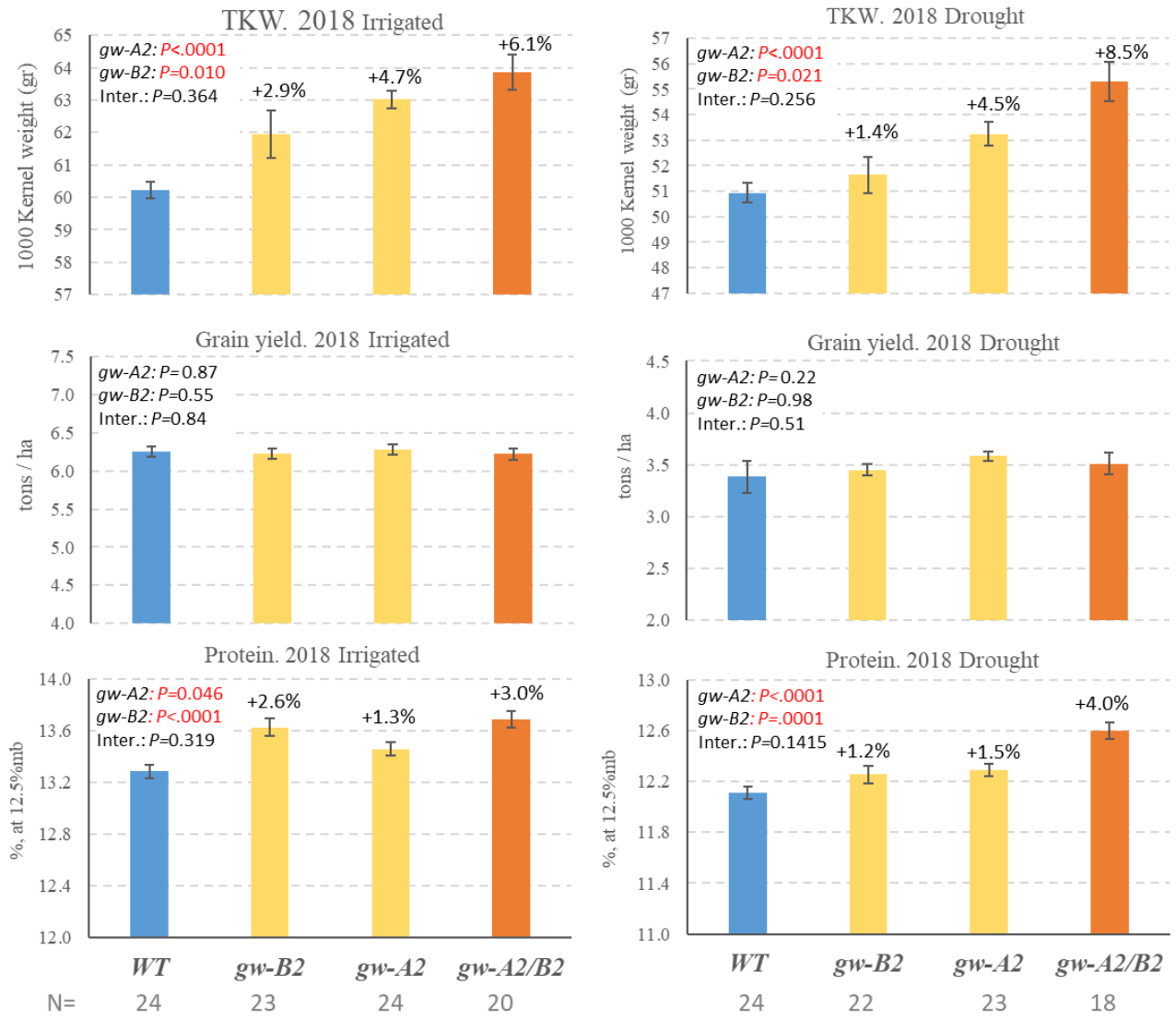

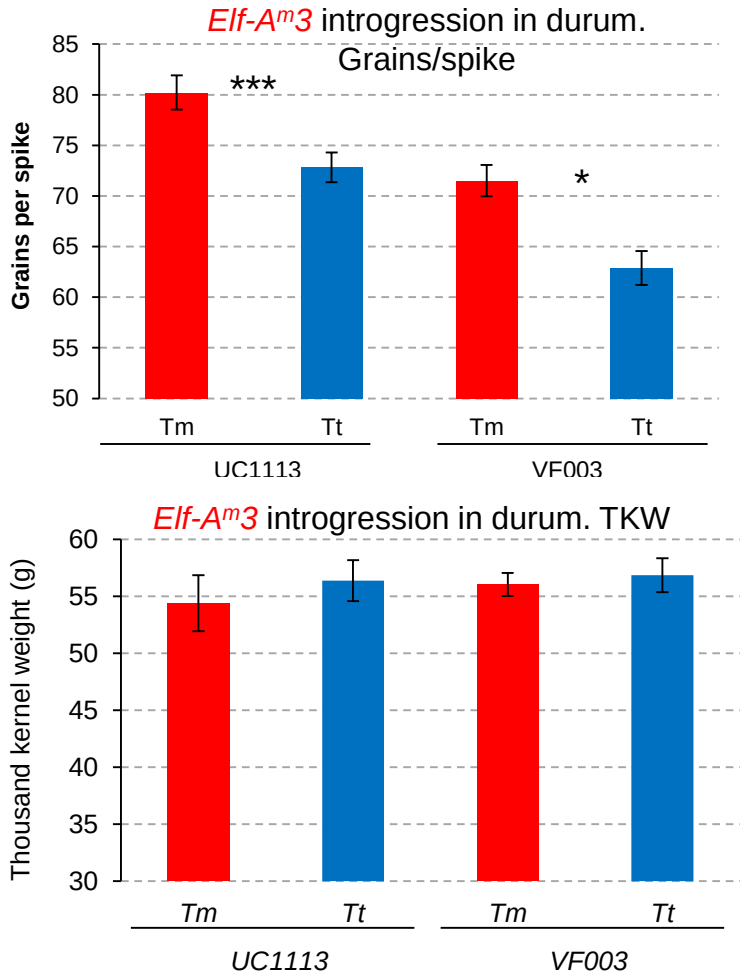

Courtesy of J. Dubcovsky, UC Davis

Combination of *Elf-A^{m}3* Allele for Grain Number and *gw2-A1* for Grain Size Shows Yield Increase in Preliminary Data

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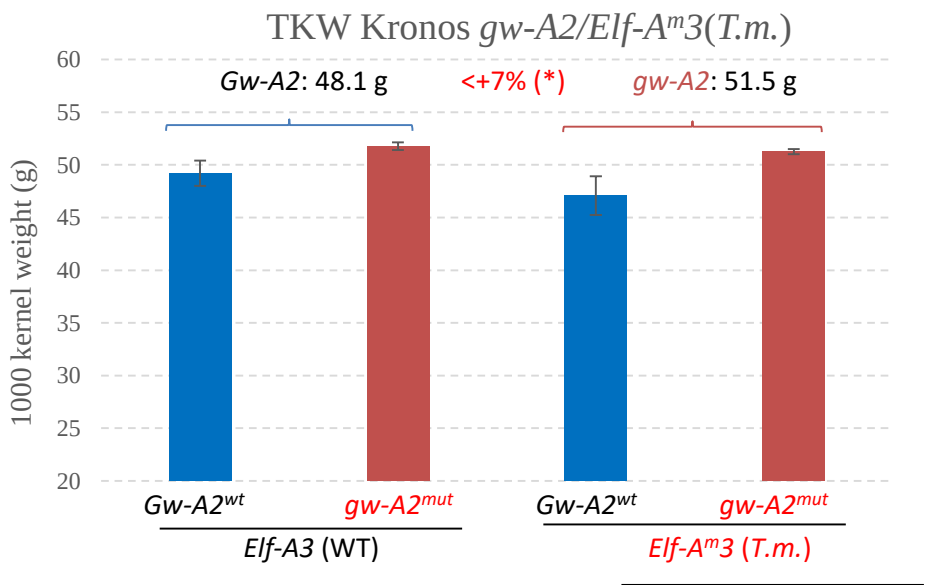
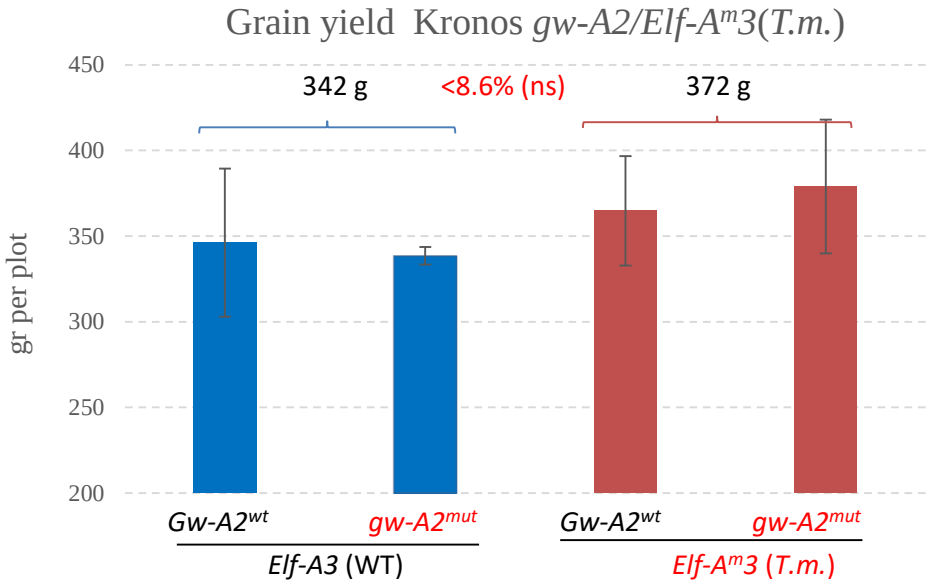
Effect of *gw-A2* and *Elf-A^{m}3* combined in Kronos (preliminary results)





Tetraploid wheat

- Isogenic BC_4F_3 lines seeds in CIRNO and GID 6420253 were sent to the IWYP Hub at CIMMYT
- Yield trials with small plots at UCD (RCBD 6 blocks) and IWYP Hub at CIMMYT

Hexaploid wheat

- Isogenic BC_4F_3 lines seeds in Kingbird available 5/2019 (more seed in 11/2019)
- Isogenic BC_4F_3 lines seeds in High-Biomass lines available in 2020

Courtesy of J. Dubcovsky, UC Davis

IWYP's Strategy is to Combine/Stack Optimized Traits by Design to Build Higher Yielding Wheat Lines

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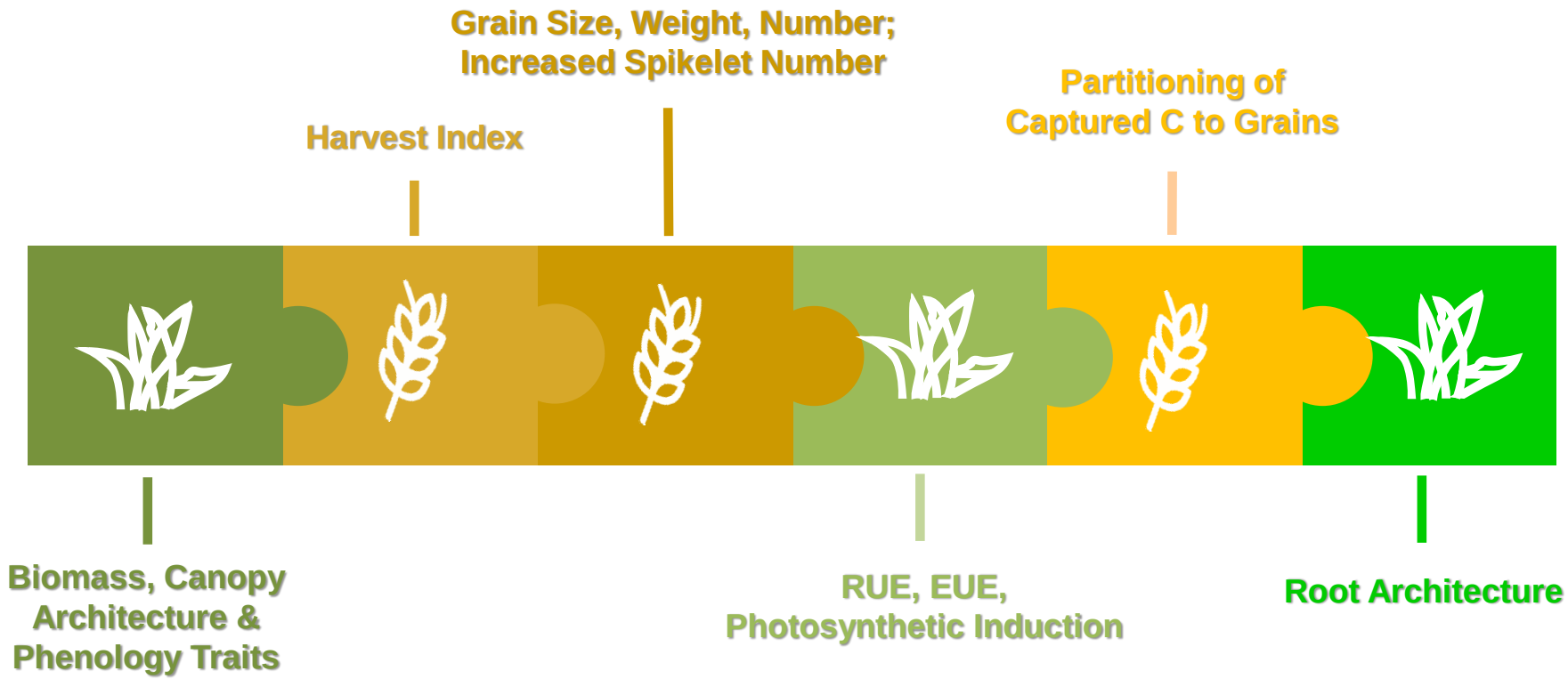
Sink Traits



Source Traits

Validation, Prebreeding and Delivery of New Higher Yielding Germplasm from the IWYP Hub at CIMMYT

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- IWYP will create sets of elite wheat lines with **different trait stacks/packages** and deliver them into public and private breeding programs – this is the primary goal
- This has already begun at the IWYP Hub at CIMMYT with the first validated traits in spring wheat backgrounds
- The new IWYP lines are further tested and disseminated via the International Wheat Information Network (IWIN) with CIMMYT and to others directly on request (*see https://iwyp.org*)

Lines Selected for High Biomass, HI, RUE Show Yield Increases in Multi-Location International Trials (4th WYCYT from CIMMYT IWIN System)

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Environment Cluster	C1	C2	C3	C4	C5	Combined
No of Environments	7	6	4	5	5	27
Yield in T/ha						
Best PT line	4.96	5.45	7.41	5.89	8.05	5.44
Best PT 3rd WYCYT	4.71	5.23	7.13	4.67	7.51	5.23
% over best PT 3rd WYCYT	5.31%	4.21%	3.93%	26.12%	7.19%	4.02%
Borlaug 100	5.29	4.46	5.45	5.65	7.28	5.09
% over Borlaug 100	-6.2%	22.3%	36.0%	4.2%	10.6%	6.9%
LSD	0.52	0.44	1.23	0.65	0.68	0.30

Courtesy of S. Sukumaran, M Reynolds, CIMMYT

The IWYP Hub Develops Pre-Products but Some Have Been Adopted as Varieties

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Year	Name	Cross / pedigree
2016	Borlaug-16	SOKOLL/3/PASTOR//HXL7573/2*BAU
2017	Kohat 17	SOKOLL/WEEBIL
2018	CASCABEL	Spot blotch resistant line (not released yet)

Courtesy of S. Sukumaran, M Reynolds, CIMMYT

IWYP Outputs (Assets) Generated Are Available to Everyone

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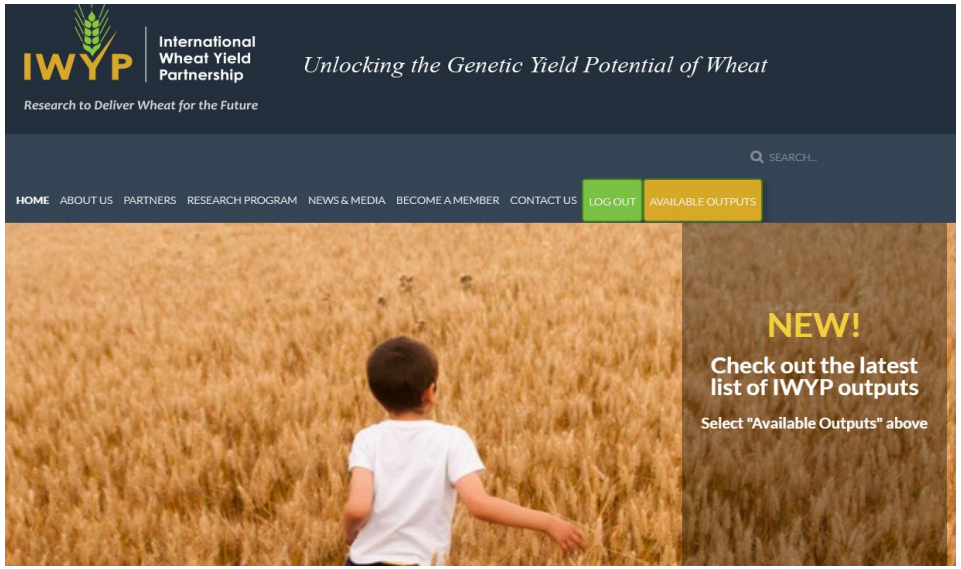

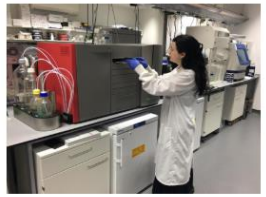

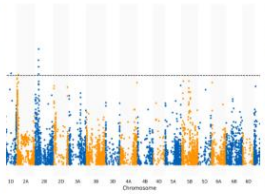

Show 10 entries Search:

Trait Name	Trait Description	Marker Name(s)	Marker Discovery Platform	Marker Conversion Technology	Validated?	Potential / Known IP?	References	Conta
Vernalization	Vernalization (spring allele)	Vrn-B1b		KASP	Yes	None		simon.
Vernalization	Vernalization G:G Winter C:C Spring	Vrn-D1a		KASP	Yes	None		simon.
Vernalization	Vernalization C:C Jagger/Claire type short vrn T:T Veery, Wichita, 2147 type long vrn	Vrn-A1		KASP	Yes	None	CerealsDB	simon.
Vernalization	Vernalization A:A-vrn-A1/others winter G:G vrn-A1a spring	Vrn-A1a		KASP	Yes	None	CerealsDB	simon.
Grain weight	Thousand grain weight	GW2-A		KASP	Yes	None	Simmonds et al 2016	cristob
Grain weight	Thousand grain weight	GW2-B		KASP	Yes	None	Wang et al 2018	cristob
Grain weight	Thousand grain weight	GW2-D		KASP	Yes	None	Wang et al 2018	cristob

Show 100 entries Search:

Tool or Protocol	Type	Description	Potential / Known IP	Reference	Contact
Whole plant gas exchange system	Lab Phenotyping	Rapidly and accurately measures water use efficiency	None	Jauregui I, Rothwell SA, Taylor SH, Parry MAJ, Carmo-Silva E, Dodd IC (2018) Whole plant chamber to examine sensitivity of cereal gas exchange to changes in evaporative demand. Plant Methods 14:97.	i.dodd@lancaster.ac.uk
Wheat Training	Website	Wheat traning website to help researchers interested in wheat navigate the different datasets and repositories available.	None	Wheat Training	cristobal.uauy@jic.ac.uk
Wheat Expression Browser	Expression analysis	Wheat Expression Browser with over 1,000 RNA-Seq datasets mapped to the RefSeqv1.1 gene models	None	Expression Browser	cristobal.uauy@jic.ac.uk
Wheat eFP	Expression	Visualisation of 210 RNA-	None	eFP Expression Browser	cristobal.uauy@jic.ac.uk

Asset Catalogues of 3 types:

- Germplasm (with traits)
- Trait Linked Markers
- Tools and Protocols

Learn More About IWYP and Join Us

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- Go to the IWYP website www.iwyp.org
- *IWYP Strategic Plan 2017-2022* (Full and Summary versions) published on the IWYP website
- *IWYP Annual Reports* published on the IWYP website::
  - *2015/16*
  - *2016/17*
  - *2017/18*

Thank You

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www.iwyp.org